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Annex to Climatological Memorandum No.34

Relative merits of alternative methods of computing mean upper air temperatures when observations are incomplete

by D. Dewar, B.Sc.

The results of an extensive investigation of the relative merits of three alternative methods of computing vector mean winds when there are missing observations and the reliability of values based on incomplete data have been published[1]. The working papers of a similar but much more limited investigation using upper air temperatures were recently found to be of value in offering advice as to the best procedure for Ocean Weather Ships to use for computing monthly mean temperatures for CLIMAT TEMP SHIP messages and it has been thought worthwhile to put on record the results of this investigation also.

Tests were carried out using three simple methods of computing the mean value when there is more than one hour of observation. The are:-

(a) to compute a daily mean value for each day from values at different hours and then to take the mean of these values.

(b) to compute a monthly mean for each hour of observation and then take the mean of these.

(c) To divide the sum of all available values by the number of observations to obtain the mean

Four complete distributions, for which the true means were known were selected viz. 400 mb data for Aldergrove in January 1959, Crawley in May 1959, 100 mb for Hemsby in November 1959 and for Aden in April 1959. Six incomplete distributions were then produced from each of the four originally complete distributions by omitting data which were missing at 50 mb (60 mb in one case) in January 1959 at six of the radio-sonde stations in the British Isles. Though this procedure did not provided an entirely random selection of data it produced six incomplete distributions which were sufficiently varied to be regarded as providing six separate tests for each of the four originally complete distributions. Table 1 below shows the types of distributions obtained. The figures apply strictly only to the two 31-day months (62 observations in complete distribution) but those for the two 30-day months were very similar.

Table 2 gives the true mean for each distribution and the errors of the means computed from the incomplete distributions by each of the methods (a), (b) and (c).

A curious feature of the results for the British stations for which only a partial explanation seems possible is that the mean temperatures computed from incomplete data are mostly too high. The values for Aldergrove at 400 mb in January can probably be explained by correlation between losses at high levels and temperatures in the troposphere at the other radio sonde stations (also in January) being reflected in a selection of the warmer ascents at Aldergrove. This explantion is not however applicable to data for Crawley in May or to data for Hemsby in November.

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As regards the merits of the three methods it is, of course, obvious that method (a) should not be used for an element having a well marked diurnal variation. An examination of the daily values used for the tests showed that, in general, there was little difference between the 00h and 12h temperatures at 400 mb but there were often appreciable differences at 100 mb. Table 2 shows that method (a) did, in fact, give the worst results for data at 100 mb where there was appreciable diurnal variation; it also shows that method (a) was the best for data at 400 mb where there was little diurnal variation.

There is little to choose between results for methods (b) and (c). Method (b) is recommended in the Guide to Climatological Practices[2] but for the computation of monthly means of temperature and height for CLIMAT TEMP SHIP messages part month totals have to be passed from one ship to another and the use of method (b) requires twice the number of groups needed for method (c) to be transmitted (and, doubles the possibility of transmission errors). It was therefore suggested that, as the tests described above had shown that method (c) was satisfactory, this method (c) should be used for computing monthly means of temperature for CLIMAT TEMP SHIP messages from OWS A, I, J and K.

An interesting feature of the results is that generally a good approximation to the true mean temperature was obtained from very incomplete data. Table 1 shows that in tests 2, 3 and 6 over half the observations were missing and that there were no data at all for about one-third of the month. Table 2 shows that, apart from the poor results for Aldergrove in Test 2, the errors of the monthly means are mostly less than 0.5°C.

References

1. Dewar, D. The computation of monthly summaries of winds from incomplete data. Climatological Memorandum No.34. Met.O.3 August 1962.

2. Geneva, World Meteorological Organization; Guide to Climatological Practice, WMO - No. 100 TP.44, Geneva, 1960, para. 11.4.

Table 1. Characteristics of incomplete distributions

Test No.	Total No. of obs.	Days with no data	Days with data for 1 hr only	Number of periods of 4 days with no data	3 days with no data	2 days with no data	4 days with data for 1 hr only	3 days with data for 1 hr only	2 days with data for 1 hr only
1	40	5	12	-	-	-	-	-	2
2	29	10	13	-	1	1	-	-	3
3	27	9	17	-	2	-	1	1	1
4	37	5	15	-	-	1	-	2	1
5	40	4	14	-	-	-	-	-	1
6	29	12	9	1	1	-	-	-	2

Table 2. Errors of means computed from incomplete distributions

Data used	Method	Test 1	2	3	4	5	6	Total error (modulus)	Max. error
		°C.							
Aldergrove	(a)	0.1	1.6	0.1	-0.2	0.5	0.0	2.5	1.6
Jan 1959, 400 mb	(b)	0.7	1.5	0.4	0.3	-0.3	1.0	4.2	1.5
Mean -38.4 °C	(c)	0.6	1.5	0.3	0.1	0.2	0.7	3.4	1.5
Crawley	(a)	0.1	0.4	0.3	0.2	0.1	0.4	1.5	0.4
May 1959, 400 mb	(b)	0.2	0.6	0.2	0.4	0.2	0.8	2.4	0.8
Mean -32.5 °C	(c)	0.2	0.6	0.2	0.3	0.2	0.8	2.3	0.8
Hemsby	(a)	0.5	0.3	0.7	0.4	0.0	0.5	2.4	0.7
Nov 1959, 100 mb	(b)	0.3	0.1	0.7	-0.1	0.1	-0.2	1.5	0.7
Mean -59.4 °C	(c)	0.4	0.1	1.0	0.1	0.1	-0.1	1.8	1.0
Aden	(a)	0.5	0.3	0.2	0.2	-0.2	-0.1	1.5	0.5
April 1959, 100 mb	(b)	0.3	-0.1	-0.3	-0.1	-0.1	-0.3	1.2	±0.3
Mean -80.2°C	(c)	0.5	0.0	0.0	0.3	-0.1	-0.2	1.1	0.5